Underwater Vehicle Coordination

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LONG-TERM GOALS

The objective of the Underwater Vehicle Coordination project is to provide enabling technologies for a cooperating system of small, inexpensive, heterogeneous Autonomous Underwater Vehicles (AUVs) for area reconnaissance, object reacquisition/identification, and mine neutralization in the Very Shallow Water (VSW)/Shallow Water region. In the VSW environments where damage is intended to valuable amphibious assets (Landing Craft Air Cushioned and other landing craft), mines are placed in random patterns and the capability to detect and neutralize these mines in a timely fashion is complicated by their sparse distribution. The system concept is to capitalize on the strengths of different classes of platforms, and to have them cooperate to perform the mission. The primary goal of this program is to develop mission control and automatic classification methodologies using cooperating AUVs in unstructured navigational environments.

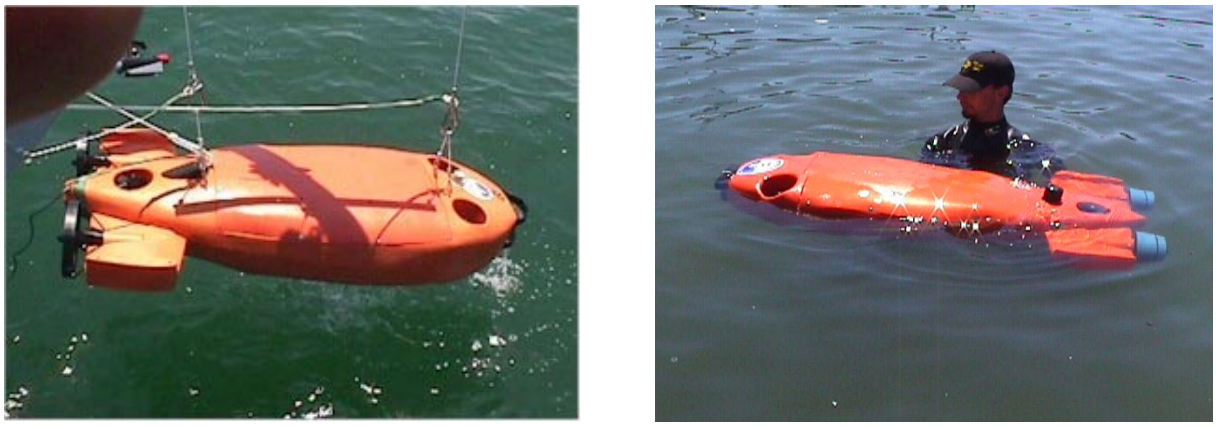
OBJECTIVES

Two AUVs, each with unique and complimentary capabilities are employed. A free-swimming, torpedo shaped, fin-controlled AUV provides for the reconnaissance of large areas rapidly and provides initial locations of mine-like objects. This reconnaissance platform will transmit detection information and data to a hovering inspection and identification platform. This platform will reacquire the suspected mines without the use of off-board navigational references. The onboard processing of sensor data, along with the platform's ability to hover and examine the object from different angles, will yield identification of the object to be a mine or non-mine. Once an object is identified as a mine, the neutralization assets may be released directly at the target site by the identification platform. If the neutralization assets are not transported to the target site by the classification platform, they will navigate by other means, and will relocate to the mine positions.

APPROACH

The Office of Naval Research (ONR) sponsored Explosive Ordnance Disposal (EOD) Robotic Work Packages (EODRWP) task has developed advanced untethered AUV technologies including sensor suites, signal processing, and vehicle management approaches which support acquisition sensor data for the autonomous detection, localization, and identification of underwater ordnance. Autonomous closed loop control, enhanced acoustic navigation, high frequency sonar-based target detection and localization, and an "intelligent" computer-based mission controller has been developed, integrated, and ocean tested. The program focused on applied signal processing with an emphasis on the reconstruction and extraction of features from sonar images.

The EODRWP has been fully integrated into the Cetus and Cetus II AUVs. Cetus and Cetus II have a flatfish shaped hull, and are designed to facilitate the employment of forward-looking sonars, video, and other sensors for target imaging. Cetus has station keeping capabilities, a 5-knot maximum speed, minimal metal part construction, and separate external battery packs for ease of replacement. Cetus II has all the features of Cetus (except it has a 3 knot maximum speed) but has more processing power and is two man portable.



a. ***b.***

Figure 1. a) At-Sea Testing of the Integrated Cetus. b) Testing of the Cetus II.

To perform the intended mission, there are four primary actions required of the system of vehicles; detection, classification, reacquisition and identification, reacquisition and neutralization. The planned work over the life of the project will progress from detection of objects by a free-swimming AUV, and the recording of locations of these objects, to reacquisition by another asset for identification of mine versus non-mine, to reacquisition by another asset for neutralization. Early project phases concentrate on detection, location/reacquisition, classification and identification. Later phases will extend capabilities to positioning the autonomous neutralization assets.

There are four main areas of supportive development required to successfully demonstrate the utility of coordinating small, inexpensive AUVs for this mission. These are navigation/positioning, communications, sensors/data processing, and automatic dynamic optimization of asset usage.

WORK COMPLETED

The Cetus vehicle was demonstrated in November 1999, at the AUV fest in Gulfport Mississippi. The Limpet Mine Imaging System (LIMIS) high-resolution sonar had not yet been integrated but the vehicle demonstrated its navigational ability by performing several search patterns. Another attempt to demonstrate the Cetus vehicle was made in March 2000 at EOD Mobile Unit 7 in San Diego. Unfortunately the vehicle was seriously damaged as it was being lowered into the water when a support cable broke. The Cetus impacted the rear of the launching boat. This cracked the seal on a pressure vessel and allowed seawater to flow into the electronics.

The primary technical focus during FY00 was the construction of the Cetus II vehicle system. This new vehicle is 2/3 the size and much lighter than the Cetus but still has all the sensor capabilities. In addition, the Cetus II requires less power and has much more computer processing power. The Cetus II vehicle system has been outfitted with a Global Positioning System (GPS) receiver which has been integrated into a Doppler Velocity Log (DVL)/ Inertial navigation system. A LIMIS high-resolution sonar has been installed in the nose of the vehicle for imaging of the sea floor.

RESULTS

The integration of the EODRWP into the Cetus II gives a more reliable and less power hungry architecture for the inspection platform of the CAUV program. The original Cetus had numerous problems as a result of obsolete and sometimes unreliable computer hardware. Lack of processing power was also a problem with the Cetus. The acoustic modem and LIMIS sonar require significant computation power and would bog down the Cetus central processor. The Cetus II with much more modern computer hardware performs tasks much faster and with less power requirements.

Although the Cetus II is a next generation AUV, it combines complex hardware and still requires significant effort to reach an operational phase. The vehicle participated in the Fleet Battle Experiment -Hotel (FBE-H) but was not yet at the point where it would perform a satisfactory search pattern. The software contained some minor errors and a circuit board on the DVL was damaged during shipment. However, the Cetus II is quickly approaching the demonstration phase and is expected to perform at the FBE-I in April 2001.

IMPACT/APPLICATIONS

The impact of having systems that navigate accurately in geodetic frames of reference is clear. Through the establishment of relative accuracies of the various elements, which establish the reconnaissance, reacquisition, and inspection, optimal evaluation of areas can be accomplished. The capability to navigate in situations, which prohibit the placement of fixed navigational aids reduces the risk associated with prosecuting hazardous areas and increases covertness of the operation. Decreased time required to deploy and conduct operations translates into more efficient and less costly operations. In addition, employing a robotic vehicle system which is truly two man portable eliminates the need to use boats equipped with special launching/retrieving hardware such as cranes and greatly increases the convenience and flexibility of the system.

TRANSITIONS

The applications of these technologies will greatly enhance Naval Special Warfare/EOD divers' ability to perform covert mine reconnaissance, identification and neutralization in the VSW environment. The successful system will transition elements to PMS-EOD for support of EOD Underwater and VSW Mine Countermeasures programs. Capabilities established also influence systems that become extensions to long range surveillance systems such as the Long-term Mine Reconnaissance System (LMRS) and the Remote Minehunting System (RMS). The short-range reconnaissance and reacquisition and intervention capabilities are directly applicable to near term procurements such as the Airborne Mine Neutralization System (AMNS).

RELATED PROGRAMS

This program is intended to investigate capabilities in advance of technology demonstrations such as those to be completed in the ONR Very Shallow Water/Surf Zone Mine Countermeasures (VSW/SZ MCM) program. Other related programs include the Autonomous Ocean Sampling Network is an ONR research project in which groups of cooperative AUVs operate from network stations to provide a long term, reactive ocean presence.